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## FLUCTUATIONS OF ATTENTION TO CUTANEOUS STIMULI.<sup>1</sup>

By L. R. GEISSLER, B. L.

Ever since the term "fluctuation of attention" came into psychological usage, it has been assumed by many psychologists that attention itself is an intermittent, oscillating, more or less rhythmically pulsating condition or state of mind. A sufficient proof of this was thought to be found in the fact that a continuous liminal stimulus periodically enters and leaves consciousness. On the other hand, it has also been shown by several investigators that the unsteadiness of liminal sensations may be due to various other causes. This would not necessarily disprove the oscillatory nature of attention. But the results of an investigation carried on during the last year tend to show that, under certain favorable conditions, maximally concentrated attention to liminal and supraliminal cutaneous stimuli remains approximately constant for at least 2 to 3 minutes, provided that physiological adaptation of the sense-organ and violently intruding external or subjective distractions can be prohibited for this length of time. This is the general outcome of a series of experiments suggested by the incongruity between the results of previous investigators of fluctuations of attention to cutaneous stimuli.

The first experiments of this kind were made in the year 1887, by N. Lange, with a Du Bois-Reymond induction coil.<sup>2</sup> The observer held one of the electrodes in the one hand and placed a finger of the other hand in a vessel of lukewarm water containing the other electrode. Lange found that fluctuations in this sense department were not as plain as in the case of visual and auditory stimuli, and in fact could be observed only after some practice. He thought the reason for this was that in daily life we are hardly ever required and therefore little accustomed to direct our attention to tactual sensations. In 1892 similar experiments were made by A. Lehmann, who also compared the occurrence and duration of electro-cutaneous fluctuations with the periods of concurrent respiration.<sup>3</sup> He

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<sup>1</sup>From the Psychological Laboratory of Cornell University.

<sup>2</sup>Beiträge zur Theorie der sinnlichen Aufmerksamkeit und der activen Apperception. *Philos. Stud.*, IV, 1888, 390 ff.

<sup>3</sup>Ueber die Beziehung zwischen Athmung und Aufmerksamkeit. *Philos. Stud.*, IX, 1893, 66 ff.

found a surprising coincidence, which led him to the conclusion that the periodical innervations of the muscles, caused by inspiration, in some way increase the sensitivity of the skin.

Observations of an entirely different kind were made by E. Wiersma, who in 1900 and 1901 investigated among other things the fluctuations of attention to areal pressure sensation.<sup>1</sup> He employed a series of 6 circular weights, 1 cm. in diameter, the lightest being 7.4g, and each following 3g heavier; so that the series extended to 22.4g. These weights ranged for him from a liminal to a distinctly supraliminal intensity. Each observation lasted 5 minutes, after which the observer rested for about 8 minutes. Wiersma found that the total time of complete imperceptibility, as well as the duration of the different periods of fluctuation during a single observation, are proportional to the intensity of the stimulus, and that toward the end of each period of observation liminal stimuli, pressure as well as visual and auditory, tend to (and often actually do) disappear entirely. This tendency of conscious processes to lapse into unconsciousness seems to him to be intrinsic to the fluctuations of sensitivity. Quite different were the results of Ferree's experiments, both with liminal pressure stimuli and with liminal electro-cutaneous sensations.<sup>2</sup> No fluctuations were experienced.

Partly for this reason, we decided to repeat his and also Wiersma's experiments. We also wished to obtain introspective data as to the course and contents of consciousness during the experiment, because we expected them to throw light on the conditions of fluctuation. According to Lange and many others, the intermittences of liminal sensations are due to central causes, *i. e.*, they represent fluctuations of attention; in other words, a liminal sensation periodically enters and leaves consciousness because attention itself is an intermittent or pulsating process. Now it may be true that a minimal lapse from maximal to a somewhat less concentrated state of attention is sufficient to cause such disappearance, without our being able introspectively to observe this slip or lapse. But if it is unnoticeable, then there is no justification for calling attention intermittent; if it is noticeable, then introspection ought to bring it to light. So far as our knowledge goes, no systematic appeal to introspection has been made by the supporters of Lange's hypothesis. On the other hand, Lange's opponents have maintained that intermittences of

<sup>1</sup>Untersuchungen über die sogenannten Aufmerksamkeitsschwankungen. *Zeits. f. Psych.*, XXVI, 1901, 168-200; XXVIII, 1902, 179-198; XXXI, 1903, 110-126.

<sup>2</sup>An Experimental Examination of the Phenomena Usually Attributed to Fluctuation of Attention. *This Journal*, XVII, 1906, 119.

liminal sensation occur in spite of the most concentrated attention, and hence must be due to something else. They have referred this phenomenon to periodical changes in the physiological conditions of the sense-organ or in the sensory centres of the cortex. Introspection would be plainly in their favor if it could tell us, not only what is in consciousness while the oscillating stimulus is subliminal, but also what is the state of attention during the absence of the original sensation; and, especially, whether it is possible for attention to remain maximal while different processes enter and leave its focus during a given period of time. From the 350 introspective records obtained during the course of our investigation, we can, in a preliminary way, draw the conclusion that after some practice it is possible to estimate the degree of attention given to a certain stimulus with fair accuracy, and to notice any shifting of the focus of attention.

#### I.

For the sake of comparison, we copied as closely as possible Wiersma's arrangements and external conditions. Unfortunately, outside noises could not be entirely avoided. But we tried to eliminate at least all visual disturbances or distractions by using the darkroom for each experiment. The fluctuations were recorded by means of a telegraph key, connected with a stylus writing on a kymograph in an adjacent room. About 300 records were obtained from the following observers: Misses M. E. Almy (A), then a Cornell summer student of slight practice in introspection, and E. Murray (M), a very careful and experienced observer, and Messrs. I. M. Bentley (B), the only observer familiar with the problem besides G, the writer, I. Lande (L), W. H. Pyle (P), and R. W. Sailor (S). Observers M, G, L, P, and S were advanced students in the department of psychology who had had general laboratory training. The first set of experiments, with observers A, B, G, and P, was made during the months of July and August; the second set, with observers L, M, P, and S, from October to December, 1906.

Preliminary trials showed that Wiersma's weights were not liminal for our observers. Nevertheless it seemed worth while for comparative purposes to use his material, and experiments were accordingly made with these weights upon P and G on 6 consecutive days in the order given by Wiersma. The experiments were also repeated for G in reversed order. In the case of the other observers, we were content with one or more observations with each of the 6 weights. At the end of each trial the observer was asked to write out an introspective account of the course and content of consciousness during the

experiment. In about 165 trials Wiersma's arrangements were exactly followed, in the remainder some modification as to weight, time, or area stimulated was introduced. The latter will be treated separately later on. The results obtained from A, B, G, and P were entirely opposed to Wiersma's. These observers recorded no fluctuations whatever, but stated that the weights could be perceived even if attention were not directed toward them. But this wandering away of attention from the stimulus occurred almost only in the second half of the experiment, that is to say, after about 150 sec. of maximal concentration; for we must remember that each observation, according to Wiersma's direction, lasted 5 minutes, which is undoubtedly too long and too fatiguing. Other characteristics of the introspective records appear in the following quotations:

*Observer A. Weight 16.4g.* "Seemed so heavy that I had only to think of it as a weight to keep it in mind. It fluctuated in apparent amount of pressure and in degree of attention, but was easily held in consciousness throughout the time."

*Weight 13.4g.* "Kept weight in mind by verbal ideas and by projecting my mind on the periphery of the weight as the sensation lessened. I allowed it to slip only once, when by comparing the two hands I decided there was no feeling; and I started to press the key and found I was feeling, though very faintly; the movement of the right hand emphasized its freedom from weight."

*Weight 10.4g.* "It almost escaped me, as I thought about the weights and what they were made of; but I snatched the pressure sensation back just as it began to fade from consciousness. I felt that the weight was too light to be held easily in mind, and I had to think of it more attentively than I should have to think of a heavier one."

*Weight 7.4g.* "Had by effort from the beginning to keep weight in first level (*i. e.*, highest degree) of attention, because it was so light and fluctuated in intensity so that I could sometimes hardly feel it. Disturbing noises once almost put it out of consciousness; nevertheless it was voluntarily held at second level. I think in words to keep my attention on it—spoken words to myself—and try to banish all other thoughts. Kept comparing the surfaces of the two hands to be sure the weight could be felt."

*Observer B. Weight 13.4g.* "Slight throbbing of blood in last part of interval. Surer this time of no fluctuations. Interrupting distractions from fatigue in arm. Some associative trains obscured stimulus. A tremendous strain!"

*Weight 10.4g.* "Heavy. Distinct throbblings of blood in back of hand and index finger. Pressure lighter in last part of interval. As before, I seem to come back to pressure and clear it up after distracting associations. Pressure seems *not* to have lapsed and returned."

*Weight 7.4g.* "In last part of experiment, bad throbbing of pulse in volar fore-arm caused some distraction. Just at end I was doubtful whether pressure was still present (yes?)."

*Observer P. Weight 19.4g.* "Attention on weight throughout, and had richer sensations than usual. Pain came in after about a minute. I thought a few times there was a flash of cold. I can still feel sensation after weight is removed."

*Weight 13.4g.* "Felt weight well. Its sensation changed, a little painful toward end. Many things passed through my mind, staying only momentarily."

*Weight 10.4g.* "I kept saying to myself: weight, weight, in order to be sure of my attention. Occasionally I felt my arm underneath and sometimes I noticed my breathing."

*Weight 7.4g.* "A little difficult at times to feel weight. I would become doubtful and attend very closely, the weight at such times then plainly felt."

"A little painful at times and very faint at last. Could hardly tell whether I felt it or not."

The introspections of G, the writer, are perhaps less valuable than the others, although in their main features they differ little from the rest. A few actual disappearances of the lightest weight, due to some unavoidable distractions, occurred in his case.

Summarizing now the observations of A, B, G, and P, we find (1) that a supraliminal areal pressure stimulus applied to the skin will gradually change its original character as to quality and intensity, and either disappear altogether after 2 or 3 minutes or persist as a simple, indefinite, vague, and unpleasant irritation, which is perhaps sometimes confused with a resulting pressure after-image. (2) These qualitative changes or fluctuations of intensity (due to physiological conditions) are noticed only when and presumably because attention is concentrated and becomes more concentrated the fainter the stimulus grows. (3) After sufficient practice it is possible to estimate with fair accuracy the degree of attention given to different stimuli or to the same stimulus at different and especially critical moments. (4) It seems probable that attention can remain maximal even while different mental processes enter and leave its focus, at least for a few minutes. (5) The weights were heavy enough to press the muscles beneath, and also to emphasize the beating of the pulse (B and G) against the resisting contact surface of the weight; these things served either as distraction or as a criterion for the presence of the stimulus. (6) The slightest movement in the upper part of the body increased the pressure to a surprising degree, probably because it involved a slight movement of the stimulated surface of the hand. The last two points serve to emphasize the fact that very close attention involves great muscular strain. It is possible that breathing, under such conditions, periodically causes greater tension and relaxation of the muscles of the chest and arms, and hence indirectly brings about the (often rhythmical: B and G) fluctuations of intensity in the pressure of the weight upon the muscles underneath the skin. Of course these results cannot fairly be compared with Wiersma's, because the stimuli were not liminal; and therefore another set of experiments had to be made for the purpose of getting liminal pressure sensations.

Unfortunately, it was impossible to continue with the same

observers, except P, and hence our new observers, L, M, and S, had to begin afresh with Wiersma's series, in order to determine whether for them these weights were liminal or not. At first sight this seemed to be the case, but the introspections proved the contrary.

For example, L recorded the following fluctuations (indicated by the minus sign preceding a number) in the first set of observations taken :

*Observer L.*

No.	Weight.	Fluctuations in Seconds.
1	7.4g	+ 58-2+179-6+25-4+13-13
2	10.4g	+136-2+11 -9+55-9+44-14+14-6
3	13.4g	+ 69-2+36 -4+42-7+32-7 +47-10+10-16+18
4	16.4g	+ 51-13+52-15+143-4+22

But the corresponding introspections plainly show that the disappearance of the sensation is due to distractions which forcibly claim attention. In a few cases, especially those toward the end of the observation, the organism gradually becomes adapted to the stimulus, which would, we may infer, be lost without recovery, were it not for certain involuntary tremors occurring in the hand or for slight movements in other parts of the body. Nevertheless, it is important to notice that the longest periods of absolute perceptibility in nos. 1, 2, and 4 lasted 179 sec., 136 sec., and 143 sec. respectively, which is characteristic for all other observations with the same stimuli, and undoubtedly indicates that attention was approximately constant and undisturbed during these periods.

In the case of S the few recorded fluctuations are plainly due to distractions of attention caused by such things as "finger ring pressure," "itching of hand," "twitching of an arm muscle," "ache in right shoulder;" by trains of ideas; or by external noises and disturbances. But with greater practice S learned more and more to disregard these distractions and the number of disappearances became less, being finally only 3 during an observation of 5 minutes. This means, of course, that the periods of absolute perceptibility became correspondingly longer, some of them lasting, for example, 99 sec., 110 sec., 180 sec., and 200 sec. S noticed also in his introspections that the quality of the sensation set up by the weight changes, being sometimes "a pricking sensation under the weight," sometimes warm, and toward the end slightly painful.

The results given by M were of a different nature. Finding

that the weight when put on the skin gave not only pressure, but also set up a complex of other cutaneous sensations, she attempted to abstract from them and to observe the pressure only. This required a constant analysis and often made it very difficult to decide whether pressure itself was still there or not. At such moments of doubt attention was easily drawn away to some other disturbing factor, and hence gave rise to a number of disappearances of the pressure, while nevertheless the weight could be perceived in terms of some other cutaneous sensation. This will come out in the following quotations:

*Observer M. Weight 22.4g.* "Numbish, unpleasant feelings; wanted to throw it off, or, sometimes, to move hand in order to see if it was still there and intensify the pressure. When no distinct pressure sensations were present, there was often a residue of vague itching or vibratory feeling, internal. On the other hand, the return of the pressure, as pressure, was always distinct, abrupt, as if weight were newly lowered on skin."

*Weight 19.4g.* "Disappearance twice correlated with a tingling in thumb, which seemed to swamp other sensations from hand. At other times distraction seemed to be a sensation in head, which pushed to front of consciousness. Many minor fluctuations of intensity, when the feeling was that while the sensation remained, it was temporarily blurred over, partly by the crowding in of sensations from other parts of the body, were not recorded."

*Weight 13.4g.* "At first easy to hold attention on pressure sensation. Got tired toward end—hard to concentrate on it again. Sensation itself attended to varies very much—pressure part seems to decrease considerably in intensity toward end. Other elements, temperature, tingling, etc., vary also from time to time. Pressing of key seems to bring pressure element abruptly back. Toward end, conscious of pressure of weight only as a vague discomfort over that area."

*Weight 10.4g.* "As above, very difficult to keep attention on pressure pure and simple—keeps shading off into faint tingling or glow (cold?). Toward end, sensations from weight, which had been vague and elusive for quite a period, came back when I coughed and involuntarily moved hand. These (pressure and cold) remained with hardly a fluctuation for rest of series, much clearer than in earlier part of record."

*Weight 7.4g.* "Blanks recorded sometimes (as above) mere lightening and returns of the pressure sensation in its setting of surrounding cutaneous sensations. Sometimes a total shift of attention to other spheres of sensation,—distraction usually visual. Toward end the sensation reappears more as heat or dull ache than as pressure."

In order to test or check these observations, M was given another series of experiments with the same weights, but with the explicit instruction to record only the intervals when there was no indication of the presence of the weight, whether perceived as pressure or in terms of some other cutaneous sensation. The results were strikingly different, for only a few subjective distractions occurred, such as were mentioned before by her as well as by the other observers. It would be interesting to know whether Wiersma found similar phenomena in his experiments, but unfortunately he gives no introspective account



of the qualitative nature of the sensations set up by the weights, and hence it is impossible to say whether his observations are of M's kind or not. A general summary of the introspective material obtained from L, M, and S, with regard to experiments on Wiersma's weights only, agrees in all of the main points with that of the first group of observers and hence need not be repeated here. The results plainly showed that Wiersma's stimuli were by no means liminal for either L, M, or S, and hence we decided to continue the experiments with lighter weights.

For this purpose we made a new set of weights, of 6g, 5g, 4g, 3g, 2.5g, 2g, 1.5g, 1g, and .5g, with the same diameter of 1 cm. The observers were L, M, P, and S, and over 100 observations were taken. We also introduced into some experiments certain variations of procedure, by changing the stimulated area, or by shortening the period of observation from 5 to 3 minutes. These changes seemed, however, to have little appreciable effect upon the results or upon the introspective accounts.

In the case of L, for example, whose earlier results were influenced by the interfering tremors of the hand, this source of disturbance was now not strong enough to shift the weights 6g, 5g, 4g, and 3g, so that they should be perceived again after having once become imperceptible. Final disappearance, probably due to physiological adaptation or perhaps fatigue, did not take place with these weights until toward the end of the second or third minute; for example, after 96 sec., 110 sec., 112 sec., 164 sec., etc. But the lightest weights, namely, 2g, 1.5g, 1g, and .5g, disappeared during the first minute and could not be recovered, save when a considerable involuntary movement or "jar" occurred in the lower left arm. This happened twice, perhaps as the result of an uncomfortable position of the arm during the particular experiment. Introspective accounts were again demanded. They show as before that for some time after disappearance attention was extremely concentrated in an effort to recover the sensation, though without success.

The results of S are very similar to L's. The same total disappearance without recovery is here noted. But again there was not the least regularity or proportionality of the period of perceptibility to the intensity of the stimulus. The shortest period of perceptibility occurred with weight 3g, which once disappeared after 18 sec., although introspection showed that attention was maximal, while the two lightest weights could be perceived for about a whole minute. The following figures are significant, as illustrating the fact that attention could be kept approximately constant to liminal cutaneous stimuli for fairly

long periods: 94 sec. for weight .5g, 68 sec. and 78 sec. for 1g, 96 sec. for 1.5g, 84 sec. for 2g, 120 sec. for 2.5g, 112 sec. for 3g, 88 sec. for 4g, 122 sec. and 144 sec. for 5g, and 197 sec. for 6g. Again, the introspections in these experiments bring out the fact that the effort to recover the lost sensation by concentration of attention was unsuccessful, and the attempt finally given up, principally because other cutaneous sensations from the lower arm as well as the other common distractions became strong and even unpleasant.

Different results were obtained with M and P. Both observers perceived even the lightest weights during the whole period of 5 minutes. Subjective distractions, such violently intruding disturbances as "jarring of floor," or "cold and ache in fingers toward end," etc., occurred to M with irregular frequency from one to five times during 5 minutes' observation, and were of very short duration. P also mentioned the occurrence of occasional momentary diversions of attention. The difference between L's and S's results on the one hand, and M's and P's results on the other, is probably due to several factors; but the introspections of the latter observers bring out mainly two. In the first place, it was very difficult for both M and P to tell exactly whether the sensation perceived in the stimulated area arose from the weight or not. To quote from introspections:

*Observer M. Weight 0.5g.* "Very light weight; attention harder to maintain (first two records show complete distractions of attention). Found myself continually tending to attend to the hand as a whole and compare with normal sensations in order to decide whether weight had disappeared; always seemed to find some kind of sensation left."

*Weight 1g.* "Much the same as above, but I found it more definitely limited to approximate area of weight. Rarely a light contact sensation; but in first part intermittent pulsing sensation as if throbbing of arteries lifted and dropped the weight; then later, muscular tension and weight feeling, deeper and as intensive as far heavier weights."

P's observations, though less explicit on the point at issue, clearly indicate that the complex character of the light weights was not perceived simultaneously, but rather successively, changing, *e. g.*, from "a very delicate touch" to temperature, generally warm, then to pain, and lastly to a "numbish indefinite something." These "different aspects of the weight," as P himself termed them, helped him in judging the pressure of the stimulus. Nevertheless, he doubted the possibility of sensing a very light weight for 5 minutes, and said that sometimes he was not sure whether what he felt was cutaneous and just below the pressing weight, or whether it was something more deeply subcutaneous, or even at a small distance from the

stimulated spot. Since M had entirely given up the attempt to analyze the sensational complex set up by the light weights, she was less easily and less often distracted, and employed, like P, every qualitative change in the stimulation as a criterion for judging the presence of the stimulus. The fact that both M and P had great difficulty in observing the actual nature of a liminal areal pressure stimulus seems to be in line with a similar difficulty which Spindler found in determining the nature of the after-effect of areal stimulation.<sup>1</sup>

This article suggested to us the second principal factor involved in the difference between M's and P's results and those of L and S. Since L and S never, M and P, however, very frequently, mentioned a long lasting after-sensation, it is possible that the latter, instead of having the actual sensation from the weight, perceived only an after-sensation which might have arisen after the weight itself had become imperceptible, though still present. At least both M and P often found that even immediately after removal of the light stimulus the previous sensation persisted without changing in any way whatever. However else the difference might be accounted for, it is not further relevant to the general conclusions to be drawn from these experiments.

Summing up the results, we arrive at the following facts and conclusions :

(1) A liminal areal stimulus applied to the skin after about a minute's time loses its original character, and either disappears altogether after the lapse of another minute or two, or persists as a simple, indefinite, vague, and unpleasant irritation.

(2) It is possible for a practised observer, under most favorable circumstances, to concentrate attention for at least 2 or 3 minutes upon an areal pressure stimulus of liminal intensity without experiencing any kind of fluctuations.

(3) Qualitative changes in the cutaneous sensation itself are noticed only while, and presumably because, attention is maximal.

(4) There is a strong tendency for attention to become more and more concentrated the fainter the stimulus grows.

(5) The muscular effort involved in maximal attention to a single liminal stimulus makes concentration during a period of 5 minutes very difficult, painful, and fatiguing.

## II.

In repeating Ferree's experiment with electro-cutaneous stimulation of the tongue, we found some difficulty in eliminat-

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<sup>1</sup> After-Sensations of Touch. *Psych. Rev.*, IV, 1897, 631 ff.

ing the touch, pressure, and taste sensations set up by the electrodes. The best results were obtained by applying a 1% solution of cocaine to the fore part of the tongue, upon which 2 strips of tin foil (Christmas-tree foil), hammered as thin as possible, were laid. The strips were connected with the interrupter of a Du Bois-Reymond induction coil. Unfortunately, the number of interruptions could not be regulated or even kept constant during a single observation, because the screw by which the interrupter was adjusted tended to work loose. The cocaine itself gave rise to certain sensations; but as soon as these began to fade away the tin foil electrodes could be applied, and were generally not perceived for a long time. The movable coil was adjusted to the limen for the different observers, which was at 10 cm. above the zero point for M and G, and at 9 cm. for L. Each experiment lasted 2 minutes, after which the observers rested as long as they desired. Toward the end of the period, adaptation, or perhaps fatigue, set in and caused the sensation to disappear altogether without recovery. About 50 observations were taken with L, M, and G, during January of this year.

The results were very similar to those with the weights, and agreed with Ferree's observations. It was impossible to avoid all subjective distractions, which were principally of two kinds. First, it is very difficult to hold the tongue perfectly motionless for more than 1 minute. After this interval it was practically impossible to avoid little involuntary movements, which sometimes caused the electrodes to shift or slip off. The other kind of distraction was due to the fact that generally, after about 70 or 80 sec., the exposed part of the tongue became more or less dry, which either resulted in the entire disappearance of the stimulus or caused the electrodes to stick fast to the tongue and exert a pull strong enough to overcome the faint electrical stimulus. In spite of these difficulties, we obtained 10 fairly good observations from each of the three observers, which plainly showed that liminal electro-cutaneous stimulation of the tongue does not give rise to intermittent sensations.

Introspective accounts were demanded after each observation, whether successful or not. The condition of the tongue immediately after the application of cocaine is described in the first three of the following introspections, while the rest are typical accounts of the experiment itself:

*Observer L.* "Tongue feels velvety when rubbed against the teeth; also there is what might be called a vague sensation of numbness, a sense of restriction."

*Observer M.* "Tongue (after cocaine) feels as if it had been burned. A thick, soft layer on surface with slight sting underneath. Tender, swollen."

*Observer G.* "Tongue feels numb, tight, or stretched, slightly

rough, sometimes burning, sometimes cold, as if melting ice was put on it; a metallic-bitter taste remains for some time and finally fades away, leaving only a vague feeling of numbness."

*Observer L.* "Current always faintly felt; much attention required; tongue numb; stronger sensations at times than at others."

"Current weak; fluctuation (*i. e.*, a total disappearance without recovery) I believe due to electrodes sticking as it were to tongue which dried from exposure. During fluctuation attention was still focussed in an effort to call the sensation back." (An unsuccessful experiment.)

*Observer M.* "Felt current distinctly as little intermittent pokes into tongue. Less difficulty with tongue than usual, *i. e.*, less wiggling. Discovered that what had once seemed like a gap in the current was really filled with minor vibrations which seemed to require an active shift of the attention to get hold of."

*Observer G.* "Intensity more regular this time; in right electrode I felt the little beatings quite distinctly. Sometimes a cold, metallic taste fused with the electro-cutaneous sensations."

Here again it seems obvious that the observers were able to notice not only any shift of attention to a source of distraction, but also whether or not attention remained maximal during a disappearance of the original sensation. The fact that it did remain constant for at least 2 minutes leads us to the two-fold conclusion (1) that liminal electro-cutaneous sensations under favorable conditions do not fluctuate, and (2) that even if interruptions occur in such sensations owing to external disturbances, attention itself may remain concentrated, merely shifting its focus from the lost sensation to the intruding distraction and back again. It seems reasonable to suppose that the disturbances would not have been sufficient to distract attention if it had not been directed to a single liminal cutaneous stimulus which is very monotonous and almost indifferent as to its affective tone, but to supraliminal stimuli or, better still, to topics of greater diversity and of higher affective coloring. This is borne out by almost daily observations in actual life, such as the intensive reading of an interesting novel, listening to a piece of music, what is generally called absent-mindedness, etc. Here certainly attention remains maximal for a considerable length of time, while there is a rapid change of the mental processes occupying the focus of attention. But fuller evidences of this fact are greatly needed, and must be obtained by a more systematic appeal to introspection with this particular end in view. That our own introspective records are not sufficiently explicit in this regard is due first to the fact that our observers tended rather to justify occurring distractions than to emphasize the periods when attention was absolutely concentrated upon the stimulus; and secondly to the fact that the stimulus set up a complex of sensations which they were eager to analyze and describe. Nevertheless, our final conclusion must be that under favorable circumstances attention focussed

upon liminal and supraliminal cutaneous sensations remains approximately constant for at least 2 to 3 minutes, provided that physiological adaptation of the sense-organ and violently intruding distractions can be avoided for this length of time. The normal course of events is that the sensation, once set up, fades out steadily and gradually in consequence of adaptation.